APPARATUS AND METHOD FOR TRANSMITTING AND RECEIVING ULTRA WIDEBAND SIGNALS

BACKGROUND OF THE INVENTION

[01] This application claims the priority of Korean Patent Application No. 10-2000-0028426 filed on May 3, 2003, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

1. Field of the Invention

[02] The present invention relates to an apparatus and method for transmitting and receiving ultra wideband (hereinafter, "UWB") signals, and more particularly, to an apparatus and method for transmitting and receiving ultra wideband signals wherein efficient data transmission according to channel conditions can be performed by applying channel information obtained from a signal received over a UWB channel to a data transmitter and changing a data transmission scheme for use in the transmitter adaptively to the UWB channel conditions. Herein, an apparatus for transmitting and receiving UWB signals will be referred to as "UWB transceiver" for the sake of convenience.

2. Description of the Related Art

[03] Wireless communication devices have recently become popular with the rapid development of wireless communication technologies. This has

brought a lot of changes in people's lifestyles. In particular, much effort has been made in research on UWB communications capable of implementing high-speed wideband wireless communications and simultaneously providing existing wireless communication services without need for any additional frequency resources.

[04] As for UWB communications, information is transmitted and received using very short pulses (whose width is 1 to 4 nsec). Since extremely short pulses are used, the bandwidth of UWB pulse signals in a frequency domain may be as broad as about 10 GHz.

[05] Such UWB pulse signals have very low duty cycles. Thus, there are advantages in that data transfer rate is very high, multiple accesses can be made, and interference effects due to multiple paths can be reduced.

[06] In case of frequency selective fading, i.e. where a transmitted signal has not arrived at a receiver due to deep fading at the worst, an existing UWB transceiver specified in currently suggested UWB standards has determined whether a given signal should be retransmitted on the basis of an acknowledge ("ACK") signal from the media access control ("MAC") level without any corrections in the physical layer ("PHY") level.

[07] More specifically, when a transmitter has sent a signal to a receiver and the receiver in turn receives the signal successfully, the MAC level in the receiver will send the transmitter a feedback ACK signal indicating the successful reception of the signal.

[08] However, if the transmitter has not received the feedback ACK signal from the receiver within a certain period of time, the transmitter will repeatedly transmit the same frame of data regardless of the current channel condition.

[09] There has been a problem in that this repeated occurrence of such an event would degrade the performance of high-speed and high-capacity UWB communication systems.

[10] Accordingly, there is a need for a method capable of performing more efficient data transmission by identifying a channel condition and changing the data transmission scheme adaptively to the identified channel condition.

SUMMARY OF THE INVENTION

[11] A primary object of the present invention is to provide a UWB transceiver and a method of transmitting and receiving UWB signals wherein data transmission can be efficiently performed according to channel condition by forwarding channel information obtained from a received signal to a data transmitter and changing the data transmission scheme in the transmitter according to the received channel condition, contrary to a related art UWB transceiver.

[12] Another object of the present invention is to allow a transmitter to adjust at least one of the channel coding rate, modulation order, and data transmission power on the basis of channel information obtained from a received signal.

[13] A further object of the present invention is to provide a system to which a Trellis-Coded Modulation ("TCM") or Turbo-Coded Modulation, i.e., a combination of channel coding and modulation/demodulation schemes, is applied.

[14] The present invention allows a signal-to-noise ratio ("SNR") obtained from a receiver to be applied to a transmitter and a data transmission scheme to be changed according to the received SNR so that data transmission can be efficiently performed according to UWB channel conditions.

[15] The data transmission scheme means that at least one of the channel coding rate, modulation order and transmission power is changed selectively or simultaneously according to the UWB channel condition that can be predicted from the received SNR. Further, channel information corresponds to information obtained from a UWB pulse signal to allow a UWB channel condition to be predicted, and it is defined as SNR, for example.

[16] The channel coding rate may be defined as a ratio i/N of the number i of information bits to the number N of the total bits including the information bits and redundant bits added for reliable data transmission during coding. Further, the modulation order may be defined as an order associated with a modulation scheme such as 4-PSK, 8-PSK and 16-PSK schemes.

[17] According to an aspect of the present invention, there is provided a UWB transceiver comprising a receiving unit configured to calculate channel information from a UWB pulse signal received over a UWB channel so that a UWB channel condition can be predicted and a data transmission scheme is

changed according to the calculated channel information, whereby information transmission can be efficiently made according to the UWB channel condition.

[18] According to another aspect of the present invention, there is also provided a UWB signal transmitting/receiving method, comprising the steps of receiving a UWB pulse signal through a UWB channel, analyzing the received UWB pulse signal and providing channel information with which a state of the UWB channel can be predicted, and determining a transmission method of information relative to the information to be transmitted according to the channel information.

BRIEF DESCRIPTION OF THE DRAWINGS

[19] The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description of exemplary embodiments when taken in conjunction with the accompanying drawings, in which:

[20] FIG. 1 is a schematic diagram illustrating a configuration of a UWB transceiver according to an embodiment of the present invention;

[21] FIG. 2 is a schematic diagram illustrating a configuration of a transmitter and receiver according to an embodiment of the present invention;

[22] FIG. 3 is a block diagram illustrating a UWB signal transmitting/receiving process according to an embodiment of the present invention;

[23] FIG. 4 is a schematic diagram illustrating a decoding 4-PSK process in the transmitter according to an embodiment of the present invention;

[24] FIG. 5 is a schematic diagram illustrating a 2/3 coding 4-PSK process in the transmitter according to an embodiment of the present invention; and

[25] FIG. 6 is a schematic diagram illustrating a 2/3 coding 8-PSK process in the transmitter according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[26] Hereinafter, an UBW transceiver and method of transmitting and receiving UWB signals according to the present invention will be described in detail with reference to the accompanying drawings.

[27] In explaining the UWB signal transmitting/receiving method using a UWB transceiver according to the present invention, since the UWB signal transmitting/receiving process performed between devices through their own UWB transceivers can be performed for each device, only the operating process for one device will be described.

[28] In explaining the configuration and operation of the UBW transceiver according to the present invention, it has been described that the present invention is implemented in a home network environment corresponding to an example of a wireless personal area network (PAN). However, it is for illustrative purposes only and it will be understood by those skilled in the art that various changes and other equivalents may be made to a module capable of efficiently changing the data transmission scheme according to the UWB channel condition.

[29] Accordingly, the true technical scope of the present invention should be construed as being defined by the appended claims.

[30] FIG. 1 is a schematic diagram illustrating the configuration of a UWB transceiver according to an embodiment of the present invention.

[31] Referring to FIG. 1, a UWB transceiver of the present invention generally comprises a transmitter 100, a receiver 200, a baseband controller 300 and a MAC 400. To implement an exemplary embodiment of the present invention, the UWB transceiver further comprises a timing synchronizer 500 for causing the transmitter and receiver 100 and 200 to be synchronized according to a control signal transmitted from the baseband controller 300, a T/R switch 600 for switching between transmitter and receiver circuits, and an antenna 700 for transmitting and receiving UWB pulse signals.

[32] The transmitter 100 performs channel coding and modulation for binary data of specific information, which is output from the baseband controller 300 and will be transmitted, to be suitable for the transmission over a UWB channel, and amplifies transmission power for the binary data and outputs the amplified binary data.

[33] The receiver 200 calculates SNR using a received UWB pulse signal, decodes the received signal into the original signal, and outputs the decoded signal to the baseband controller 300.

[34] The baseband controller 300 performs overall operation control for processing the transmission and reception of the UWB pulses through the transmitter and the receiver 100 and 200, and comprises a channel information

processor 310 for extracting the SNR calculated by the receiver 200 and applying the extracted SNR to the transmitter 100, a timing controller 320 for generating a timing control signal for synchronization between the transmitter 100 and the receiver 200 in connection with a modulation order for the signal to be transmitted and transmitting the generated control signal to the timing synchronizer 500, and a power controller 330 for generating another control signal in response to the SNR extracted by the channel information processor 310 and controlling the transmission power for the UWB pulse signal.

[35] Since the respective components of the baseband controller 300 will operate independently, the baseband controller 300 may be configured differently according to the data transmission scheme.

[36] For example, in a case where the data transmission scheme is only allowed to adjust the channel coding rate and/or the modulation order, the baseband controller 300 would comprise the channel information processor 310 and the timing controller 320. If the data transmission scheme is allowed to further adjust the transmission power, the baseband controller 300 further comprises the power controller 330.

[37] MAC 400 manages UWB data communication, which will be performed in the Physical Layer Part specified in IEEE 802.15.3 wireless personal area network (WPAN).

[38] FIG. 2 is a schematic diagram illustrating the configuration a transmitter and receiver according to an embodiment of the present invention.

[39] Referring to FIG. 2, the transmitter 100 comprises a channel encoder 110 for performing channel coding for binary data of specific information, which is output from the baseband controller 300 and will be transmitted, at a predetermined channel coding rate (i/N) suitable for transmission over a UWB channel, a modulator 120 for modulating the signal coded by the channel encoder 110 with a predetermined modulation order (M-ary) to generate a UWB pulse signal, and an amplifier 130 for amplifying transmission power for the UWB pulse signal output from the modulator 120 so as to be suitable for the UWB channel transmission.

[40] The receiver 200 comprises a correlation detector 210 for calculating the SNR value for the UWB pulse signal received through the antenna 700 over the UWB channel, and a decoder 220 for decoding the data sequence of the received UWB pulse signal into the original signal.

[41] If a UWB pulse signal is initially transmitted through the transmitter 100, the receiver 200 will receive a feedback signal, e.g. an ACK signal, transmitted from a specific device for receiving the transmitted UWB pulse signal, and then cause the correlation detector 210 to calculate the SNR value.

[42] The transmitter 100 and the receiver 200 are connected to the baseband controller 300, as illustrated in FIG. 2. Accordingly, the transmitter 100 will receive the SNR value calculated in the receiver 200 through the channel information processor 310 of the baseband controller 300.

[43] The transmitter 100 processes the information to be transmitted by determining the channel coding rate of the channel encoder 110 and/or the

modulation order of the modulator 120 according to the channel information received from the baseband controller 300.

[44] For example, if the UWB channel condition, which can be predicted based on the SNR value, is determined as good, the channel coding rate will be increased approximately up to "1" in such a manner as "1/4 -> 1/2 -> 3/4 -> 1", or the modulation scheme will be changed from a 4-PSK (phase shift keying) modulation scheme to a 16-PSK modulation scheme in such a manner that the modulation order will be increased, or both of the channel coding rate and modulation order will be increased.

[45] On the other hand, if the UWB channel condition is determined as bad, the signal will be processed by lowering the coding rate or modulation order.

[46] In addition, the transmission power of the amplifier 130 will be adjusted according to the power control signal transmitted from the baseband controller 300, based on the channel information.

[47] For reference, in the UWB transceiver according to an embodiment of the present invention, the SNR is calculated by the receiving unit 200, but it may be configured so that the SNR is calculated by at least one module of the transmitting unit 100, the receiving unit 200 and the baseband controller.

[48] Therefore, it will fall within a scope and spirit of the present invention that the UWB transceiver according to an embodiment of the present invention is configured in hardware or software, and it will also be apparent that various changes and modifications can be made thereto without departing from the scope and spirit of the present invention.

[49] Next, a UWB signal transmitting/receiving method using the UWB transceiver configured according to the present invention will be described in detail with reference to the accompanying drawings.

[50] The UWB signal transmitting/receiving method of the present invention generally comprises the steps of receiving a UWB pulse signal through a UWB channel, analyzing the received UWB pulse signal and providing channel information with which a state of the UWB channel can be predicted, and determining a transmission method of information relative to the information to be transmitted according to the channel information.

[51] Hereinafter, the UWB signal transmitting/receiving method of the present invention will be described in detail with reference to the accompanying drawings.

[52] FIG. 3 is a block diagram illustrating a UWB signal transmitting/receiving process in accordance with an embodiment of the present invention.

[53] Referring to FIG. 3, if a UWB transceiver ("first UWB transceiver") in a specific network device ("first device") intends to communicate with a UWB transceiver ("second UWB transceiver") in another predetermined network device ("second device"), the first UWB transceiver in the first device can transmit a message requesting data communications, in the form of a beacon signal, to the second device via a predetermined piconet coordinator (PNC) to confirm whether data communications can be made with the second network device, and then confirm whether the data communication can be made based

on an ACK signal transmitted from the second UWB transceiver in the second device.

[54] From the above process, if it is determined that data communication can be made between the first and second devices, a binary signal of the information, which is output from the baseband controller 300 and will be transmitted, is input to the transmitter 100 in the first UWB transceiver (S1). Then, the input binary signal is processed such that it can be transmitted to the second device over the UWB channel.

[55] That is, the channel encoder 110 in the transmitter 100 performs channel coding for the binary signal input from the baseband controller 300 at a predetermined coding rate (S2), and then, the modulator 120 performs modulation for the channel coded binary signal with a predetermined modulation order (S3).

[56] At this time, since the binary signal to be transmitted is an initially transmitted signal, it will be coded to a channel at the lowest coding rate and then modulated with the lowest modulation order.

[57] Then, the modulated UWB pulse signal is output to the antenna 700 so that it can be transmitted to the second device over the UWB channel (S4).

[58] Next, the second UWB transceiver in the second device receives the UWB pulse signal transmitted from the first device through the antenna 700 over the UWB channel and transmits an ACK signal for the received UWB pulse signal to the first device.

[59] If the second UWB transceiver in the second device receives the UWB pulse signal transmitted from the first network device through the antenna 700 over the UWB channel (S5), a receiver in the first UWB transceiver causes the correlation detector 210 to calculate an SNR value from the received UWB pulse signal (S6) and the decoder 220 to decode the channel coded data sequence (S7), and outputs the decoded data sequence to the baseband controller 300 (S8).

[60] The baseband controller 300 outputs the decoded binary signal to MAC 400, and extracts the SNR value calculated from the receiver 200 and forwards the SNR value, as channel information, to the transmitter 100 such that the channel coding rate and the modulation order can be determined in the transmitter 100 based on the channel information (S9).

[61] The transmitter 100 predicts the UWB channel condition based on the SNR value input from the baseband controller 300 and selectively determines the channel coding rate, modulation order or transmission power according to the predicted channel condition after the binary signal to be transmitted is received from the baseband controller 300.

[62] That is, the channel encoder 110 in the transmitter 100 causes the binary signal input from the baseband controller 300 to be coded at a channel coding rate as determined according to the predicted UWB channel condition, the modulator 120 causes the channel coded binary signal to be modulated with the modulation order determined according to the predicted UWB

channel condition, or both of the channel coding and modulation are performed.

[63] Alternatively, the transmission power of the amplifier 130 is adjusted according to the predicted UWB channel condition so that the UWB pulse signal can be transmitted through the antenna 700 over the UWB channel.

[64] In this way, the data modulation scheme in the transmitter 100 according to the UWB channel condition will be repeatedly changed according to the SNR value obtained from the UWB pulse signal transmitted to the receiver 200.

[65] By way of example, when a movie is played from a digital video disc (DVD) player onto a Digital Television (DTV) through a UWB data communication therebetween, the DVD player transmits a message requesting data communication with the DTV, as a beacon signal, to the PNC via the transmitter 100 in the UWB transceiver.

[66] Then, PNC transmits the received signal requesting the data communication to the DTV and simultaneously forwards an ACK signal received from the transmitter 100 in the UWB transceiver of the DTV to the DVD player, thereby identifying whether data communication between the DVD player and the DTV can be made.

[67] The DVD player that has received the ACK signal from the DTV outputs movie data, which are divided into frames of a predetermined size according to the UWB communication protocol and will be transmitted to the

DTV, to the transmitter 100 in the UWB transceiver through the baseband controller 300.

[68] To transmit the movie data input into the transmitter 100 of the UWB transceiver, the input movie data are coded to a channel in the channel encoder 110 and the channel coded signal is modulated in the modulator 120 and amplified up to the predetermined transmission power in the amplifier 130.

[69] In this process, at least one of the channel coding, modulation and amplification for the input data are determined depending on the UWB channel condition predicted according to the SNR value calculated from the ACK signal which has been received at the receiver 200 from the DTV.

[70] A case where the UWB channel condition predicted based on the initially calculated SNR value is determined as bad, and thus a decoding 4-PSK modulation scheme is performed, will be first discussed. If the binary signal to be transmitted is given as "00 01 01 11", the modulator 120 causes two bits to be grouped into one symbol and then each symbol to be modulated into a corresponding analog signal (S_0 S_1 S_1 S_3) as illustrated in FIG. 4.

[71] Alternatively, another case where the UWB channel condition predicted based on the initially calculated SNR value is determined as bad, and thus channel encoding at 2/3 coding rate (i.e., two information bits and one redundant bit) and 4-PSK modulation are performed, will be discussed. If the binary signal to be transmitted is given as "00 01 01 11", the channel encoder 110 performs the channel coding for the binary signal into "000 011 011 111" and the modulator 120 causes two bits of the encoded signal "000

011 011 111" to be grouped into one symbol and then each symbol to be modulated into a corresponding analog signal (S_0 S_0 S_3 S_1 S_3 S_3).

[72] In other words, the transmitter 100 in the DVD player performs the selective channel coding according to the UWB channel condition predicted based on the SNR value calculated by the receiver 200, modulates the coded signal using the 4-PSK modulation scheme, and transmits the modulated signal through the antenna over the UWB channel. On the other hand, the UWB transceiver in the DTV receives the movie data, which are received over the UWB channel and modulated into the UWB pulse signal in the receiver 200, and then transmits an ACK signal for the received signal to the DVD player.

[73] In the DVD player, the receiver 200 of the UWB transceiver calculates the SNR value based on the ACK signal transmitted from the DTV and the baseband controller 300 forwards the calculated SNR value to the transmitter 100.

[74] The transmitter 100 determines the channel coding rate, modulation order or output voltage level for the movie data to be newly transmitted according to the UWB channel condition predicted according to the input SNR value.

[75] In a case where only the modulation order is changed according to the UWB channel condition, the modulation order is increased and an 8-PSK modulation scheme is selected if the UWB channel condition has become good.

[76] That is, if the binary signal to be transmitted is given as "00 01 01 11", as shown in FIG. 6, the channel encoder 110 causes the binary signal to be channel coded into "000 011 011 111" and the modulator 120 causes three bits of the encoded signal "000 011 011 111" to be grouped into one symbol and each symbol to be modulated into a corresponding analog signal (S_0 S_3 S_3 S_7).

[77] Therefore, since the present invention allows the size of symbol for data transmission to be changed by adjusting the modulation order in the modulator according to the UWB channel condition, the UWB pulse signal can be efficiently transmitted.

[78] According to the above-described embodiment of the present invention, at least one of the channel coding rate, modulation order and data transmission power is changed so as to efficiently transmit a UWB pulse signal. However, it is also possible to adjust a predetermined parameter appropriately selected so as to increase an efficiency of the transmission signal depending upon a configuration of a communication mode or a communication device.

[79] According to the present invention, efficient data transmission/reception can be made by changing the data transmission scheme in accordance with the UWB channel condition.

[80] Further, at least one of the channel coding rate, modulation order and data transmission power can be properly adjusted so as to efficiently transmit the UWB pulse signal.

[81] Although the present invention has been described in detail in connection with the exemplary embodiments of the present invention, it will be apparent to those skilled in the art that various changes and modifications can be made thereto without departing from the spirit and scope of the invention. Thus, simple modifications to the embodiments of the present invention fall within the scope of the present invention.